Probing Isospin Violation Under Strong Magnetic Fields via the Production of $K^{*0,\pm}$ Mesons in Heavy-Ion Collisions at RHIC

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Abstract

Neutral and charged vector mesons can be sensitive to isospin-violating effects induced by Landau level splitting in the presence of a strong magnetic field (B) within a QCD medium [1]. One such example is the neutral K^{*0} ($d\bar{s}$) and the charged K^{*+} ($u\bar{s}$), which have similar masses and isospin. However, the magnetic moments of their constituent quarks differ significantly, by approximately a factor of five. The recent observation of isospin violation in neutral and charged kaons by NA61/SHINE challenges the assumption of isospin symmetry in QCD, though the cause remains unknown [2]. A difference in $K^{*0,\pm}$ yields due to B-field can feeddown ($K^{*0} \rightarrow K^{\pm} + \pi^{\mp}$, $K^{*\pm} \rightarrow K^{0}_{S} + \pi^{\pm}$) into the inclusive neutral and charged kaon yields, and contribute to the above apparent isospin violation.

In this talk, we will discuss the invariant mass peak position and its width, transverse momentum (p_T) spectra, yields (dN/dy), and $\langle p_T \rangle$ of $K^{*0,\pm}$ mesons near mid-rapidity, utilizing collisions involving isospin-asymmetric nuclei (Au+Au, Ru+Ru, Zr+Zr) and isospin-symmetric nuclei (O+O), as well as p+p collisions at $\sqrt{s_{NN}} = 200$ GeV. We report on particle ratios, including $K^{*\pm}/K^{*0}$ and $K^{\pm}/K^{0}_{S}$, as a function of p_T and centrality in various heavy-ion collision systems. Results from p+p collisions, which are expected to have no B-field effect, serve as a good baseline. Additionally, results from BES-II Au+Au collisions ($\sqrt{s_{NN}} = 7.7 - 19.6$ GeV) will be presented to study the energy dependence of the above ratios. This study will provide comprehensive understanding of Landau levels, isospin violation, and late-stage B-fields in QCD medium.

References

[1] K. Xu et. al., Phys. Lett. B 809, 135706 (2020)

[2] H. Adhikary et. al, (NA61/SHINE collaboration), 2312.06572